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(54) Optical modulator

(57) An optical device is disclosed for the external modulation of the output 4 of an optical radiation source. The device includes a first optical modulator 2 driven by an NRZ coded electrical data signal 3 so as to modulate the output 4 of an optical radiation source. The device also includes a second optical modulator 6 coupled to the first optical modulator 1 and driven by one or more drive signal sources 7, 8 from electrical circuit 9. The cir-

cuit 9 drives modulator 6 so as to provide an optical AND function to convert the NRZ coded optical signal output the first optical modulator 1 into an RZ coded optical signal and to simultaneously introduce a degree of phase modulation (e.g. pre-chirp) in the RZ signals modulated thereby.

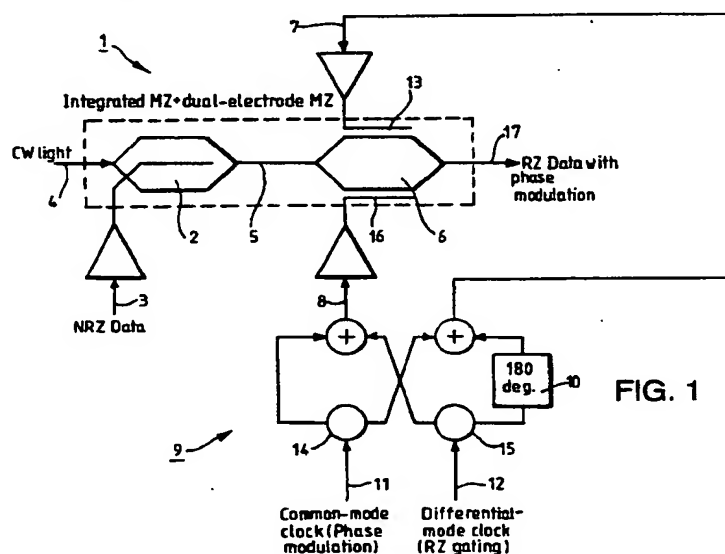


FIG. 1

Description

Background to the Invention

[0001] Optical transmission systems are generally based on one of two methods of modulation of a signal laser, either direct or external modulation. In the first of these, the bias current to the laser is modulated, turning the laser on and off. The disadvantage of this when applied to high capacity systems is that the semiconductor material dynamic behaviour introduces distortion into the laser output, known as chirp. External modulation of the continuous wave (CW) source produces a modulated output signal with significantly reduced chirp, and sources of this type are preferred for use in high capacity systems. High speed electrode-optic modulators such as Mach Zehnder devices are typically used.

[0002] One coding format for optical signals in fibre optic networks is non-return-to-zero (NRZ). In this format a coded data pulse fills the time slot corresponding to a bit period and if the next data bit has the same value no transition occurs at the end of the time slot. An example of a modulator which is designed to implement NRZ format transmission is the X2624C Mach Zehnder optoelectronic device available from Lucent. This is a dual electrode Mach Zehnder device which uses an electrical data stream and its inverse to drive respective electrodes, thereby gating (modulating) a CW source to provide NRZ optical data. By altering the two drive levels on the respective electrodes it is possible to affect a degree of pre-chirp (positive or negative) to compensate for non-linear transmission effects.

[0003] An alternative to NRZ coding is to use a return-to-zero (RZ) format. In this case, if the data in a time slot is a "1", the signal drops back to the "0" level before the end of the slot, whatever the value of the data in the next bit: a "1" is signified by the presence of a pulse located within the bit period. RZ format is more stable than NRZ coded optical signals at high bit rates, and is therefore preferred for high capacity long haul transmission systems.

[0004] One known arrangement for coding an RZ optical signal requires a first Mach Zehnder device to modulate a CW source using NRZ electrical data as the drive signal, the output of which is modulated by a second Mach Zehnder device configured as an optical AND gate to convert the NRZ optical input to an RZ optical signal at the output. The output of the second Mach Zehnder device is then coupled to a phase modulator to provide a degree of pre-chirp to compensate for non-linear transmission effects. It is not possible to provide an integrated package and therefore this solution is much more complex.

[0005] The latest 10 Gbit s⁻¹ WDM optical transmission systems that are being proposed for submarine networks will provide 60 or more channels with a spacing of only 0.4nm. In future, 120 channels having a spacing of only 0.2nm will be offered. One problem with

the development of high capacity systems such as these is that the footprint of the terminals required to support the systems are becoming increasingly large at a time when customers are demanding ever smaller integrated solutions to their needs. The preferred RZ coding format for high bit rate systems and the associated optical devices described above required to generate an RZ coded signal from an NRZ electrical data stream makes this difficult to achieve.

Summary of the Invention

[0006] According to a first aspect of the present invention, an optical device for the external modulation of the output of an optical source, comprises:

a first optical modulation device driven by an NRZ coded electrical data stream to modulate the output of the optical source to generate an NRZ coded optical signal; and,

a second optical modulation device coupled to the output of the first optical modulation device and driven by one or more sources to implement an optical AND function and controllable to introduce a predetermined degree of phase modulation to thereby convert the NRZ coded optical signal from the first optical modulation device to a phase modulated RZ coded optical signal for subsequent transmission.

[0007] According to a second aspect of the present invention, an optical modulator comprises a dual electrode Mach Zehnder device driven by one or more sources to implement an optical AND function and thereby convert an NRZ coded optical signal at an input to an RZ coded optical signal at an output.

[0008] Preferably, the one or more sources comprise an electrical circuit for controlling the drive of electrodes of the dual electrode Mach Zehnder device to modulate the phase of the coded optical signal and thereby introduce a predetermined degree of pre-chirp to the RZ coded optical signal at the output.

Brief Description of the Drawings

[0009] Examples of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a first example of an optical modulator in accordance with the present invention; and, Figure 2 shows a second example of an optical modulator in accordance with the present invention.

Detailed Description

[0010] Figure 1 shows an example of an optical modulator 1 consisting of a pair of Mach Zehnder

devices. A first Mach Zehnder device 2 is gated by an NRZ electrical data signal 3 to modulate an optical output 4 of a CW optical source (not shown) to generate an NRZ coded optical signal at an optical output 5. The NRZ coded optical signal output 5 is then coupled to the second of the two Mach Zehnder devices 6.

[0011] The second Mach Zehnder device 6 is a dual electrode device, in this example a 20 Gbit s⁻¹ X2624C available from Lucent, gated by signals 7 and 8, respectively, derived from an electrical summation circuit 9 having a phase shifter 10 and fed by a common mode clock signal 11 and a differential mode clock signal 12.

[0012] As shown, one electrode 13 of the dual electrode Mach Zehnder device 6 is gated by a signal 7 derived by summing the signal 11 from a common mode clock (not shown) coupled by a first splitter 14 with a differential mode clock signal 12 coupled by a second splitter 15 via the phase shifter 10. The other electrode 16 is gated by a simple summation of signals coupled from respective splitters 14 and 15 associated with the same clock sources. Each of the clock signals in this example is assumed to be derived from the clock used to drive the data. In this manner, the dual electrode Mach Zehnder 6 may be driven in such a way as to provide intensity modulation when the electrodes are driven anti-phase or phase modulation if both electrodes are driven in-phase. By applying suitable sinusoidal drive signals to each electrode, resultant in-phase and antiphase signals can be resolved, so the device simultaneously operates as both a phase and intensity modulator. For instance if both electrodes are driven in anti-phase with similar sinusoids then no phase modulation will occur, however if one electrode is driven with double the level and the other is inactive, then there will be phase modulation in addition to amplitude modulation. If the phase and amplitude of each of the clock signals 11 and 12 are varied it is possible to change the position and magnitude of the chirp, whilst independently controlling the Mach Zehnder drive signal level.

[0013] The second Mach Zehnder device 6 is driven to provide an optical AND function to convert the NRZ coded optical signal to an RZ coded optical signal with a controllable degree of phase modulation (pre-chirp) at an optical output 17. In use, the optical output 17 represents one channel in a high capacity WDM transmission signal. The two Mach Zehnder devices can be integrated on the same wafer and are therefore extremely space efficient.

[0014] Figure 2 shows another example of an optical modulator 20 which is similar to the example shown in Figure 1, with the exception that a single fixed clock source (not shown) is used in the electrical drive circuit 21 for the dual electrode Mach Zehnder device 6.

[0015] In this example, the first electrode 13 is gated by a signal derived by passing a clock signal 22 through a first variable attenuation circuit 23 and then a first variable phase shifter circuit 24. Likewise, the second electrode 16 is gated by passing the clock signal 22

through a second variable attenuation circuit 25 and then a second variable phase shifter circuit 26. Once again, by applying suitable drive signals, the dual electrode device 6 can simultaneously operate as both a phase and intensity modulator to generate an RZ coded optical signal with a controllable degree of phase modulation (pre-chirp) at the optical output 17.

Claims

1. An optical device for the external modulation of the output of an optical source, comprising:

a first optical modulation device driven by an NRZ coded electrical data stream to modulate the output of the optical source to generate an NRZ coded optical signal; and,
a second optical modulation device coupled to the output of the first optical modulation device and driven by one or more sources to implement an optical AND function and controllable to introduce a predetermined degree of phase modulation to thereby convert the NRZ coded optical signal from the first optical modulation device to a phase modulated RZ coded optical signal for subsequent transmission.

2. An optical device according to claim 1, in which the first optical modulation device is a Mach Zehnder device.
3. An optical device according to claim 1 or 2, in which the second optical modulation device is a dual electrode Mach Zehnder device.
4. An optical device according to any preceding claim, in which the first optical modulation device and the second optical modulation device are integrated.
5. An optical device according to any preceding claim, in which the one or more sources comprise an electrical circuit for controlling the drive of the second optical modulation device to modulate the phase of the coded optical signal and thereby introduce a predetermined degree of pre-chirp to the RZ coded optical signal at the output.
6. An optical device according to claim 5, in which the electrical circuit comprises a first splitter and a second splitter each driven by a respective clock signal, and a first summer and a second summer, wherein the first summer outputs a signal derived by summing the respective clock signals output by the first and second splitters and the second summer outputs a signal derived by summing one clock signal with a phase shifted version of the other.
7. An optical device according to claim 6, further com-

prising a phase shifter for introducing a predetermined phase shift in one of the clock signals.

8. An optical device according to any of claims 1 to 5,
in which the electrical circuit comprises a clock 5
source coupled to a first variable attenuation circuit
and a first variable phase shifter circuit connected
in series and also a second variable attenuation cir- 10
cuit and a second variable phase shifter circuit con-
nected in series, to thereby provide two separate
drive signals for the second optical modulation
device.
9. An optical modulator comprising a dual electrode
Mach Zehnder device driven by one or more 15
sources to implement an optical AND function and
thereby convert an NRZ coded optical signal at an
input to an RZ coded optical signal at an output.
10. A device according to claim 9, in which the one or 20
more sources comprise an electrical circuit for con-
trolling the drive of electrodes of the dual electrode
Mach Zehnder device to modulate the phase of the
coded optical signal and thereby introduce a prede- 25
termined degree of pre-chirp to the RZ coded opti-
cal signal at the output.

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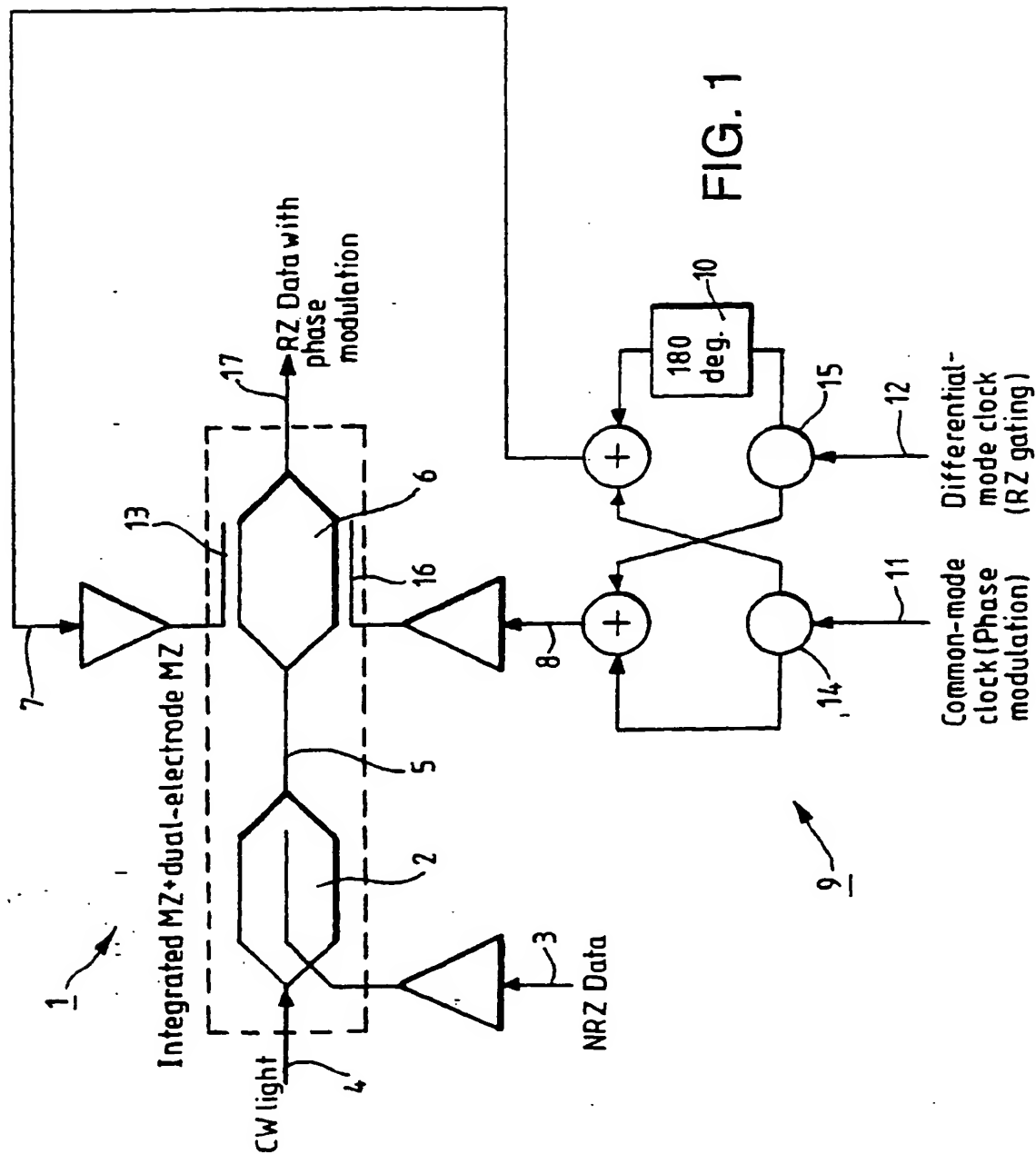
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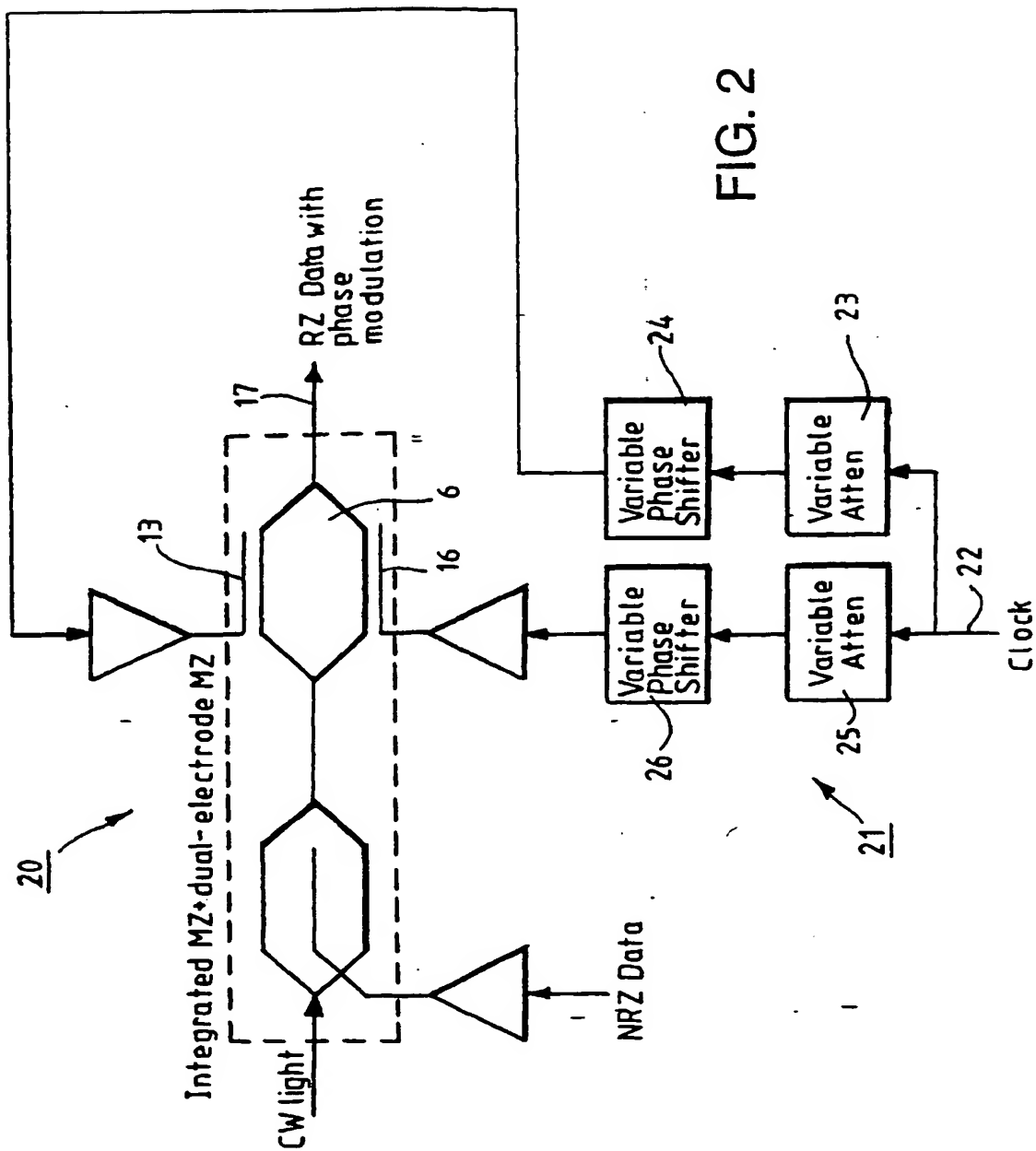


FIG. 2

(19)



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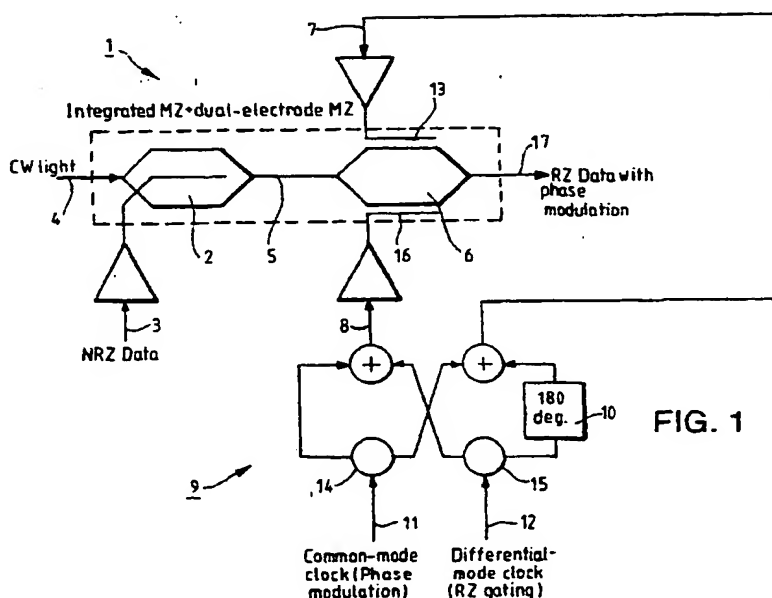


FIG. 1

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European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 00 30 7820

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search:		Date of completion of the search	Examiner
THE HAGUE		28 August 2001	Gill, R
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background C : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons A : member of the same patent family, corresponding document</p>			

EP 00 30 7820 A3 (1999-03-03)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 00 30 7820

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28-08-2001

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